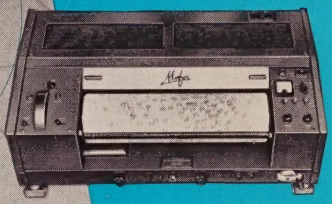
MUIRHEAD

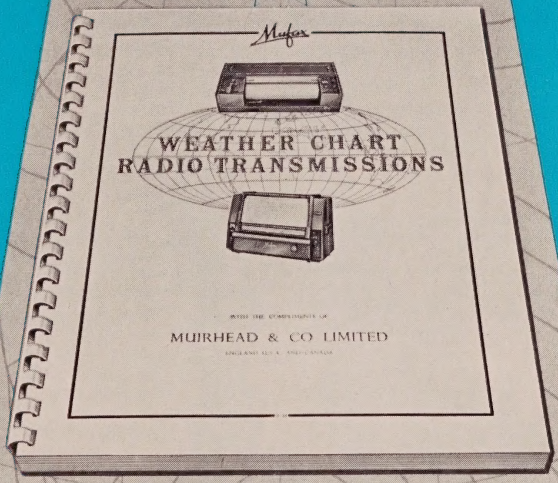
TECHNIQUE

A JOURNAL OF INSTRUMENT ENGINEERING
VOLUME 16 NUMBER 2 APRIL 1962

D-655-B

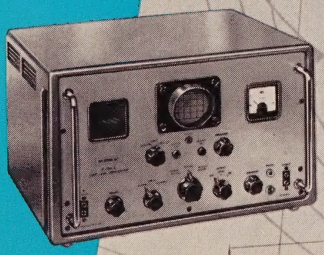


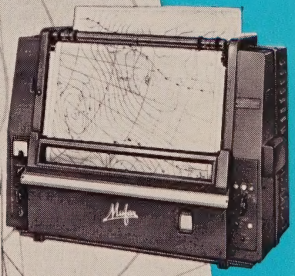
D-658D/A

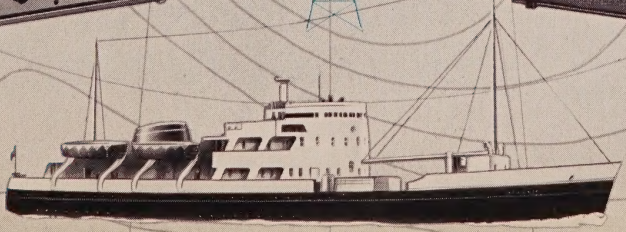


D-649-L

K-156-A







MUIRHEAD

R. J. STANLEY
EDITOR

Technique

A JOURNAL OF INSTRUMENT ENGINEERING

APRIL 1962 · VOLUME 16 · NUMBER 2

MUIRHEAD & CO., LIMITED · BECKENHAM · KENT · ENGLAND

Telephone: Beckenham 4888 *Telegrams and Cables:* MUIRHEAD, BECKENHAM

CANADA
MUIRHEAD INSTRUMENTS LIMITED
STRATFORD · ONTARIO
Telephone: 271, 3880
Cables: MUIRINST, STRATFORDONT

U.S.A.
MUIRHEAD INSTRUMENTS INC.
441 Lexington Avenue · New York 17 · N.Y.
Telephone: Murray Hill 2-8131
Cables: MUIRINST, NEW YORK

IN THIS ISSUE

THE USE OF TELEPHONE CIRCUITS FOR FACSIMILE TESTS ON 48 kc/s GROUP CIRCUITS FOR NEWSPAPER PAGE TRANSMISSION Page 11
by E. T. A. Phillips

MEASUREMENT OF VIBRATION AND NOISE IN MOTOR VEHICLES Page 14
by J. C. Coyle, A.M.Inst.E.

RELEVANT LITERATURE

Catalogue Sheet 100 D-489 Muirhead Pametrada Wave Analyser.
Catalogue Sheet 101 K-101 Automatic Recording Wave Analyser.

THE FRONT COVER

The front cover of this issue depicts in graphical form the function of the Publication 'Weather Chart Radio Transmissions', which is available free on request from Muirhead & Co., Limited. This publication contains details of the times frequencies and chart contents of the transmissions that are made by twenty-five stations throughout the world, many of which use Mufax equipment. The information given is under constant review and amendments, when required, are issued quarterly.

Details of the instruments illustrated are contained in catalogue sheets
625, D-658 Mufax Chart Transmitters
630, D-649 Mufax Chart Recorders
634, D-655-B AM/FM Conversion Unit,
K-156-A F.S.K /A.M. Conversion Unit

ANNOUNCING THE NEW ABRIDGED CATALOGUE — 1962

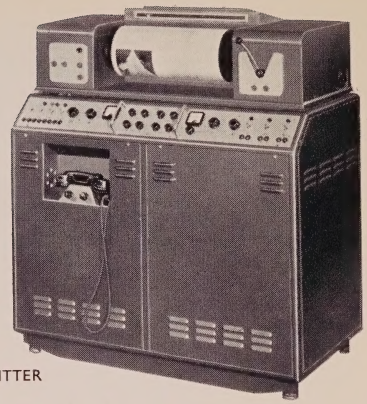
We are pleased to announce the issue of our new Abridged Catalogue of Precision Electrical Instruments.
This publication lists instruments in the following categories:
Instruments
Resistors, Resistance Networks and Inductors
Components and Cells
Servo, Control and Indication Equipment
Synchros and Magslips
Facsimile Communications Equipment
The basic features of each instrument are presented in concise form for quick and easy assimilation and as such, the catalogue is invaluable to all who have little time to wade through masses of technical literature
The Abridged Catalogue is available immediately on request.

ARTICLES FOR 'TECHNIQUE'

The Editor would welcome articles for publication in *Technique*, for which liberal payments are made. Articles of 1,200 to 1,500 words plus illustrative matter would be considered for acceptance if related to the use of Muirhead instruments in a particular field of endeavour.

THE USE OF TELEPHONE CIRCUITS FOR FACSIMILE TESTS ON 48 kc/s GROUP CIRCUITS FOR NEWSPAPER PAGE TRANSMISSION

by E. T. A. Phillips*



D-854 TRANSMITTER

The first facsimile system of newspaper transmission in the world was put into operation with Muirhead equipment by the Asahi Shimbun of Tokyo in June 1959, and subsequently showed itself to be a most satisfactory method of reproducing newspapers in towns far distant from the main plant. Nevertheless, this installation operated on a circuit composed entirely of microwave radio connexions, and prospective users in other countries as well as ourselves as manufacturers, were anxious to gather information on the performance of the equipment on other forms of 'group' circuit connexions. Accordingly, through the co-operation of prospective users and the administrations concerned, practical tests were carried out in the United Kingdom, Italy and West Germany on typical 48 kc/s groups in the telephone networks of these countries.

The facsimile apparatus used was the Muirhead D-854/5 page facsimile equipment which has been fully described in a previous issue of *Technique*. Essentially, it comprises a transmitter/receiver installation whereby two newspaper pages measuring $23\frac{1}{2} \times 16\frac{1}{2}$ in. may be transmitted simultaneously in a time of 27 minutes. The scanning drums rotate at 180 rev/min. and the scanning density is 300 lines/inch. Two facsimile channels of 22 kc/s width are accommodated in the 48 kc/s group, together with a 3 kc/s synchronizing channel. The maximum keying frequency is 10·8 kc/s, which suggests a maximum permissible circuit delay distortion of approximately $\pm 25\ \mu$S if the normally accepted distortion limit of 1/2 element (or one 'bit') is adopted. The actual band of frequencies transmitted is the basic group of 60–108 kc/s.

Of the various sources of distortion which can mar the received facsimile copy, it was considered that the three most troublesome would be the delay distortion introduced by filters (particularly the through-group types), extraneous interfering signals on coaxial systems, and noise on the local ends. Special attention was, therefore, given to these features of the circuits under test.

United Kingdom trials

The tests carried out in London were conducted from an office in the Fleet Street area and through the courtesy of the G.P.O. Engineering Department, three typical group circuits were set up, each starting and finishing in London.

The first circuit was in a coaxial system and was looped back at Manchester. The second was the upper half of a 24-circuit carrier system looped at Glasgow. The third circuit was of a composite type, looped at Salisbury, and consisted of Group 1 in a coaxial system in the outward direction and the lower half of a 24-circuit carrier system in the return direction. The Manchester circuit was 400 miles long, the Glasgow circuit 800 miles, and the Salisbury circuit 200 miles. These circuits are shown in Fig. 1.

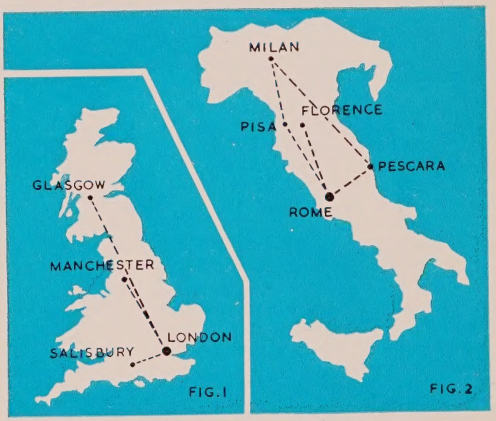


FIG. 1

FIG. 2

The connexions available between the fac-

* Chief Engineer, Facsimile Laboratory: Muirhead & Co. Limited.

simile equipment and the London carrier terminal were normal exchange lines as used for local telephone distribution, two miles in length and made up of 6½ and 20 lb. unloaded underground cable. Before proceeding with the main line tests, it was considered necessary to make complete tests over these local ends to determine whether they would be suitable for carrying the facsimile signal or whether temporary coaxial leads would be required. Preliminary measurements of insertion loss and noise level were made during the busiest hours of the day and these showed that the loop loss of the circuits was 22dB at 61 kc/s and 25dB at 94 kc/s with noise levels of – 43dBm (wide-band) and – 60dBm (60–108 kc/s). These results being more optimistic than had been expected, transmissions were made round the local ends alone. The received copies were found to be completely free from distortion.

Transmissions on the main circuits were then commenced and the first results showed delay distortion in evidence on both circuits when using the facsimile channel A (63–85 kc/s). This was not unexpected since the Glasgow circuit contained four 24-circuit filters and the Manchester circuit included three through-group filters. The remedial action taken was the raising of the facsimile carrier from 3 kc/s below mid-band to 3 kc/s above mid-band. This reduced the side-band power in that part of the frequency spectrum which experienced a high degree of delay distortion in the filters. Subsequent transmissions showed no evidence of this form of distortion.

The transmissions on the upper facsimile channel, channel B (86–108 kc/s), were distortionless on the Glasgow circuit but an interfering pattern was noticeable on the Manchester coaxial circuit. This was found to be due to an interfering frequency of 96 kc/s, which is an intermodulation product on the No. 7 coaxial system and which occurs on Groups 3, 4 and 5 of the system. It was understood that this frequency can be reduced to a level which is innocuous for facsimile purposes, but for the remainder of the tests the circuit was changed to make use of Group 1, on which the interference does not occur. It is understood that Group 2 is also unaffected.

Test transmissions continued for two weeks during which various minor alterations were made for experimental purposes and, finally, the composite circuit via Salisbury was tried and found to be distortionless provided that Groups 1 or 2 were used in the coaxial system.

The conclusions drawn were that 24-circuit carrier systems containing at least four filters, and coaxial systems containing at least three through-group filters are satisfactory for the Muirhead equipment provided that Groups 1 or 2 are used in the coaxial system or, alternatively, steps are taken to reduce the 96 kc/s intermodulation produced in Groups 3, 4 and 5. Fig. 4 shows the delay characteristic of a typical 24 cct filter, and Fig. 5 that of a typical through-group filter. The local end loss in any one direction should not exceed 25 dB and the noise level within the 60–108 kc/s band should not be greater than – 30 dBm. Additionally, the spread of attenuation within each facsimile channel should not exceed 3 dB, and the insertion loss figures should be considered in relation to minimum level requirements at the carrier terminal in the transmit direction and the level available from the terminal in the return direction. For the London tests, the transmitted signal was connected into the carrier system on the group distribution frame at the level of – 37dBm and was returned from the G.D.F. at a level of – 8 dBm. Transformers with impedance ratio 140 ohm: 75 ohm were used to match the local ends (140 ohm at 100kc/s) into the 75 ohm balanced input/output circuits of the facsimile equipment.

Italian tests

The tests in Italy were carried out in the Repeater Station of the P.T.T. in Rome and, consequently, no local ends were involved. Three main circuits were provided by the P.T.T., all starting and finishing in Rome. The first, 2000 miles long, was a mixed coaxial cable and micro-wave radio system — the micro-wave section being between Rome and Pescara and the coaxial system from Pescara to Milan, where the circuit was looped back. Groups 2, 3 and 4 of the coaxial system were used during the trials. The second circuit made available was entirely coaxial and was routed via Pisa and Milan, total length 2000 miles. The third circuit was entirely micro-wave radio and was a loop circuit via Florence. Connexion of the facsimile signal into the system was identical with that used by the G.P.O. in London, and the results of the tests over the circuits showed similar tendencies to those found in the U.K. series. These circuits are illustrated in Fig. 2.

Since only one through-group filter was used in each of the P.T.T. circuits, no delay distortion was encountered. There were, nevertheless, three super group transitions on circuit No. 1 and four such transitions on circuit No. 2 but these did not introduce any noticeable distortion on the received copy. As was anticipated, interference patterns were visible on the facsimile copies when using channel B (86–108 kc/s) on Groups 3 and 4 of the coaxial systems. These patterns, although detectable, were not of sufficient magnitude to spoil the received copies, and a measurement of the interfering signal showed it to be of 96 kc/s at a level 35dB below the 'black' facsimile level (the maximum level of the facsimile signal). An additional through-group filter was subsequently added to one of the circuits but no delay distortion was noticed on the received facsimile copies.

West German tests

For the third series of tests, a number of circuits were set up by the West German Bundespost using Hamburg as the sending and receiving terminal. Three circuit types were made available; the Kx.V.960 coaxial system, the V.120.C balanced pair carrier system and the

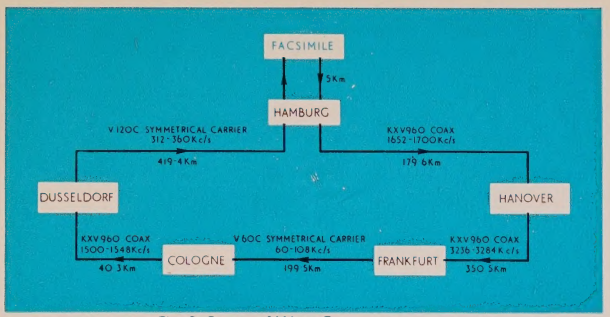


Fig. 3. Route of West German tests

V.60.C carrier system. Fig. 3 shows the intermediate towns and the circuit types used between them.

By looping the circuit back at Hamburg again it was possible to provide a circuit which was 1400 miles long and which included no less than 11 through-group filters and 20 super group transitions! As was expected, considerable delay distortion was apparent on both facsimile channels — A and B; that on channel B being so great as to destroy the usefulness of the received negative, that on channel A being not so large but sufficient to render the received copy of doubtful value. With the circuit complexity reduced to six through-group filters and ten super group transitions by routing the circuit Hamburg–Hamburg through all the other towns, the received copies on both channels were usable although delay distortion was evident.

A large number of comprehensive tests were subsequently made which proved that page transmission was a successful proposition on all the Bundespost circuits of practical length and complexity. As with the previous series of tests, some problems were encountered with interfering frequencies but these could be overcome by the avoidance of certain troublesome groups, and by the introduction of band-stop filters to eliminate the pilot test frequencies which are a feature of the West German Bundespost circuits. Projected trials on the forward-scatter radio system to Berlin had, unfortunately, to be abandoned owing to heavy traffic demands on the circuits.

The local ends in Hamburg were normal exchange lines, 3 miles in length, with an insertion loss at 60 kc/s of 15·5 dB. Transmissions over these ends alone showed no distortion whatsoever. Connexions into the carrier terminal equipment were as in London, but the received level from the terminal was lower, being – 37·5 dBm.

Conclusions

The prime conclusion to be drawn from the large number of line tests carried out is that page facsimile transmission is a workable system over all the common forms of 'group' telephone circuits. Certain precautions must be taken to avoid interference with the facsimile signal by intermodulation products in the carrier cable and coaxial cable system by reduction of their amplitudes, or by selecting groups in which they do not occur. Band-stop filters are necessary on the West German circuits to remove the 84·08 kc/s pilot frequency.

The most remarkable feature of the whole series of tests is the tolerance shown by the facsimile receiver to the delay distortion introduced by through-group filters. Up to seven of these filters could be included in the circuits before the received facsimile copy became unacceptable to the printer — a practical result which is very much at variance with theory, as can be seen from the generalized through-group filter characteristic shown in Fig. 5. The explanation is probably twofold: firstly, the

Continued on page 16

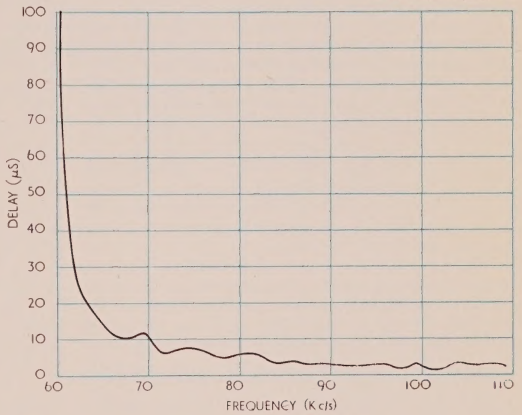


Fig. 4. Delay characteristics of a 24 oct Filter

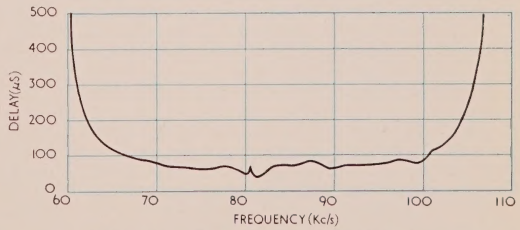


Fig. 5. Delay characteristic of a Through-Group Filter

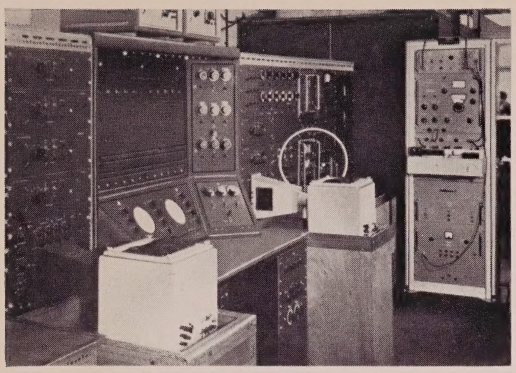


Fig. 1. Interior of the Central Recording Room.

MEASUREMENT OF VIBRATION AND NOISE IN MOTOR VEHICLES

by J. C. Coyle, A.M.Inst.E.*

In the development of a motor car which is traditionally silent and smooth, a large amount of research must be carried out in the fields of vibration and noise suppression. To this end Rolls-Royce installed in their Motor Car Division some years ago, a central recording system which is connected by land lines to their test beds, experimental garage and rig shop. When the equipment was first installed, the manually operated D-489 Muirhead Pametrada Wave Analyser formed an important part of the system and was used in noise investigation, the measurement of torsional vibrations and engine and car roughness.

As experience was gained in the use of electronics in the development of motor cars, it became obvious that the work could be divided into two main groups, one which required the attention of a highly skilled man and the other that was routine and could be carried out by some form of automatic machine. We felt the need for such a machine was so great that an electric motor and drive was connected to the main control on the D-489 Analyser and for some time this equipment was used with a fair degree of success.

†The K-100 Automatic Recording Wave Analyser

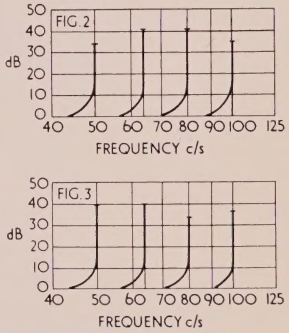
When the K-100 Automatic Recording Wave Analyser became available, one was installed in the central recording room of the Motor Car Division. It comprises a D-940 Analyser with automatic switch facilities, a D-976 Recorder which can be operated in either of two modes XY (amplitude/frequency) or X time (amplitude/time) and a K-28 stepping unit. The K-28 is used when the input signals to the analyser are derived from a magnetic tape recorder playing a continuous loop of tape. Its function is to advance the frequency of the analyser by one step at the end of each cycle of the tape loop.

Fig. 1 shows part of the interior of the central recording room; the K-100 Automatic Analyser may be seen in the background with the K-489 Wave Analyser at shelf level towards the rear of the main rack.

The suppression of vibration or noise requires that the electrical signals produced by transducers, from pressure variations and movement, be analysed in order to identify the source. Vibration measurement requires an analyser of narrow bandwidth since the excitation source is usually constant, whereas with noise, which is more of a random nature, a wider bandwidth is needed if some degree of repeatability is to be obtained from the measurements. A bandwidth of 1/3 octave has now been accepted as about 'the right amount'.

Measurement and recording of noise

The usual practice when measuring noise in motor vehicles is to record the noise for a number of seconds on a tape recorder whilst the vehicle is passing over a test track. This tape is then made into a continuous loop and played back into an analyser of some sort in the laboratory. The amplitude of the recorded noise fluctuates rapidly because of the random excitation the car receives from the road surface via the tyres and suspension, and the technician is faced with the difficulty of deciding what reading he will take for his answer while the needle of the meter on his wave analyser dances from one end of the scale to the other.



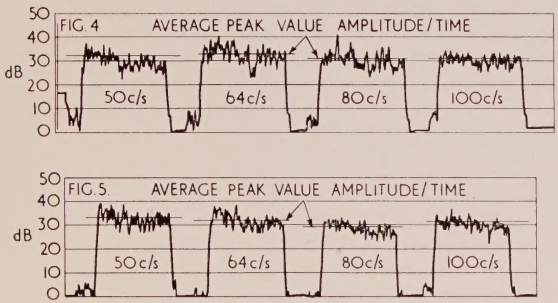
Figs. 2 & 3. Representative peak noise levels — AMPLITUDE/FREQUENCY

If an amplitude/frequency recorder is used to

* Head of the Electronics & Vibration Laboratory, Rolls-Royce Motor Car Division. † K-101 now supersedes K-100.

print these answers the value it will record will be the peak value of the noise the microphone has heard during any one run. This can, in fact, produce quite the wrong impression, as Figs. 2 and 3 illustrate.

Fig. 2 shows the analysis of a noise recording made in the front head position of a motor car whilst it was being driven over a noise generating surface at 45 miles per hour. Fig. 3 is an analysis of the same car being driven over the noise generating surface for the second time. The conditions for the test in each case were similar. It can be seen from the graphs that quite large differences in noise levels are apparent and at 80 c/s the level varies by as much as 8 dB. Since the car has not been changed in any way between the two recordings it is felt that these large peaks may have been caused by loose stones from the road coming in contact



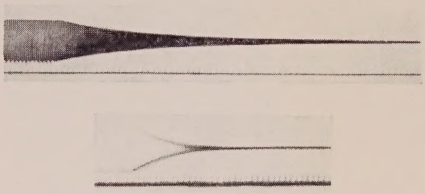
Figs. 4 & 5. Representative average peak noise values — AMPLITUDE/TIME

with the underside of the body and, therefore, may be neglected. It has been realized for some time that the repeatability obtained from recording to recording has not been satisfactory and if anything is to be gained from noise recordings, a better method of analysis must be adopted. If the peak values shown in Figs. 2 and 3 are ignored and an amplitude/time plot is made of the recording (Figs. 4 and 5), it is possible by consideration of how the amplitude of the signal varies with time, to arrive at a figure of merit for each frequency. It is not possible to calculate this figure very easily, but with experience and subjective impressions gained from people riding in the car it is possible to decide what the answer will be. We are of the opinion that if a reasonable average value is taken through the peaks obtained at each frequency from an amplitude/time record, the answer obtained is found to agree with the subjective impression gained in the car. Figs. 4 and 5 show what we consider to be a 'reasonable average peak value', and it is our intention in the future to analyse our noise recordings in this manner.

Further advantages that have resulted from the use of this analyser are that since most of the noise that proves objectionable in our motor cars ranges in frequency from circa 30 c/s to 500 c/s, an analysis can be made in approximately 2½ minutes, and copies of graphs required for report purposes can be obtained at further intervals of 2½ minutes.

Noise damping

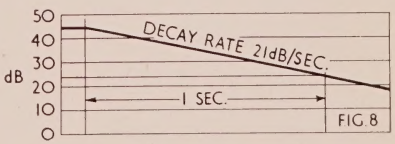
When the engineer has obtained a picture of the noise spectrum in the car, he is faced with the problem of what to do in order to produce an



Figs. 6 & 7. Decay rate: (*above*) 25 dB/sec. (*below*) 100 dB/sec.

end product that is quiet enough to be acceptable with regard to the high standards set by his customers. The noise level in a car is dependent to some degree on the response of the various body panels to vibrations reaching them from the wheels, via the suspension and chassis. It follows that the noise level will be reduced by damping the resonance of any panel and by preventing forced frequencies of large amplitudes from building up.

Panel damping materials are available for this purpose and the investigation of their relative damping qualities and the technique of their application to panels, is carried out at Rolls-Royce. For this purpose a rig has been constructed so that the conditions of test may be reproduced exactly for each material. This rig consists of a flat steel plate of sufficient weight never to be critically damped by any test material applied to it. The plate is tuned to vibrate in its fundamental mode at 150 c/s and is vibrated by an electromagnet. The pressure fluctuations produced by the vibrations of the plate are converted into an electrical signal by the use of a microphone. When the power to the magnet is switched off, the decay of the signal is measured with respect to time. One way of doing this is to photograph the decay of the signal as it appears on the screen of the



oscilloscope and Figs. 6 and 7 show the typical sort of picture obtained. From these pictures it is possible, after fairly lengthy calculations, to

arrive at a figure from the decay rate of the material under test. The amplitude of the signal produced by the vibrations of the plate can be seen from Figs. 6 and 7 to decay logarithmically with respect to time when the exciting force has been removed. If this signal is coupled to the K-940 Analyser in its flat state the output from the analyser will pass to the D-976 Recorder via a logarithmic potentiometer. The record thus produced will be a logarithmic amplitude plot. Fig. 8 shows a typical record obtained in this way. By intelligent use of the information obtained from these tests, much can be done to produce a quieter motor car.

Measurement and recording of engine vibration

Further contributions to passenger comfort can be obtained by installing in a car an engine which is quiet in operation and relatively free from vibration. The development work carried out on internal combustion engines frequently involves the measurement of torsional vibrations in the crankshaft. These measurements are made at Rolls-Royce using an inductive torsiograph in conjunction with a frequency modulated system, the output of which is fed into the K-100 Wave Analyser.

In making torsional vibration measurements, it is customary to observe how the overall amplitude of the vibration varies with the speed, and afterwards to examine the peaks in more detail for their frequency and amplitude components. When the overall amplitudes of the vibrations have been observed it is possible to determine from the peaks in the amplitude/speed curves the speeds at which resonance of the crankshaft occurs. This information can then be passed on to the operator who is running the engine on the test bed. When the engine has been set to one of these predetermined speeds, the analyser is started remotely by the tester. A change of speed is indicated to him automatically when the analyser has completed its programme, by the closing of a pair of contacts that are already in the machine, causing a signal lamp to be illuminated. In this way a completed torsional vibration test may be carried out by one man without the necessity of a skilled technician being in attendance throughout the test.

Conclusion

The speed at which the electronic engineer can extract information from his equipment has always been an important factor in the race against time whenever a new product is being developed or an old one improved upon. We feel that the addition of this instrument to our central recording system has been of some assistance to us in making the answers to our problems available to the development engineer in a shorter time than was possible before.

Continued from page 13

delay distortion occurs mainly at the edges of the filter pass-band where the side-band power of the facsimile signal is small; secondly, the nature of the received facsimile is a black-and-white reproduction having transparent characters on a dense black background wherein the second image caused by delay distortion is lost during the photographic processing. It is very doubtful whether a continuous-tone facsimile system would be as tolerant.

The performance of exchange lines as local ends for facsimile working in the relatively high frequency band employed is also encouraging. Most of the prospective users of page facsimile equipment are situated within a short distance from the local carrier terminal.

In closing, the writer wishes to acknowledge, gratefully, the facilities and assistance very readily given by the newspaper organizations concerned in the series of tests, and by the administrations involved. In particular, we wish to thank Mr. J. E. Haworth and colleagues of the G.P.O. in London, Dr. Digano of the Rome P.T.T., and Hr. Koesel and colleagues of the West German Bundespost in Bonn.

Muirhead engineers who collaborated in the tests were:

D. Banks, E. Thomason and R. Brook.

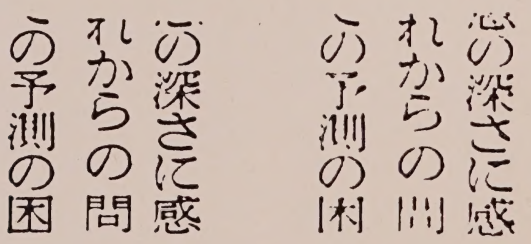


Fig. 6. Enlargement of transmitted Japanese characters (*left*) acceptable, (*right*) unacceptable due to delay distortion.

The copyright of all articles in this journal is strictly reserved, but the material may be reprinted without permission provided definite acknowledgment is made to Muirhead & Co., Limited, the publishers

22749 BM

Printed in England